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L. K. Hervig

E. M. Noddin

R. R. Vickers, Jr.

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NAVAL HEALTH RESEARCH CENTER
P. O. BOX 85122
SAN DIEGO, CALIFORNIA 92186 – 5122

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
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MOOD EFFECTS OF EXPOSURE TO LOW FREQUENCY ACTIVE SONAR: REPLICATION AND EXTENSION†

Linda K. Hervig[1]

Ernest M. Noddin[2]

Ross R. Vickers, Jr.[1]

[1]Cognitive Performance and Psychophysiology Department
Naval Health Research Center
P.O. Box 85122
San Diego, CA 92186-5122

[2]Naval Submarine Medical Research Laboratory
Box 900, Naval Submarine Base, New London
Groton, CT 06349-5900

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Summary

Problem

Navy personnel onboard ships are exposed to sonar as part of their normal work environment. Low frequency active sonar (LFAS) exposure effects must be established to define cost-benefit functions for ship designs with different levels of soundproofing.

Objective

The objective of this study was to quantify the effects of LFAS exposure on indicators of morale.

Approach

Navy enlisted men (n = 33) participated in the five-day laboratory study. The first study day included introduction and familiarization with the testing procedures and completion of background and personality inventories. A standardized questionnaire for mood and activation was completed twice daily on the second through fourth days of the study. Mood/activation measures taken on the second study day provided a baseline for comparison to similar measures taken on the third study day after a 24-hour LFAS exposure. LFAS exposure intensities differed across groups of subjects from 77 dB (n=12) to 83 dB (n=10) to a maximum of 89 dB (n=11). Mood/activation measures taken on the fourth study day were compared to those from the third day to assess recovery from LFAS exposure.

Results

Comparisons between the 77 dB and 89 dB LFAS exposure groups indicated:

(a) Significant mood and activation changes were observed during LFAS exposure and recovery, but the magnitude of these changes was the same for both LFAS intensities.

(b) Personality variables predicted how individuals responded to LFAS exposure, but relationships between personality and mood/activation were not affected by LFAS intensity.

Conclusion

Different LFAS intensities in the 77 dB to 89 dB range produce comparable effects on mood and activation. In the 77 dB to 89 dB range, mood/activation effects need not be a concern for ship design decisions unless the present results change under longer exposure times which may be more typical of Navy shipboard environments during operational deployments.

Introduction

Navy personnel aboard ships often are exposed to sonar in their normal work environments. The noise generated by sonar can adversely affect mood and cognitive performance (Hockey, 1986) and may produce perceptions that the work situation is more stressful than would be the case otherwise (Driskell et al., 1991). These effects of sonar exposure may worsen when exposure is uncontrollable (Glass & Singer, 1972) as it generally is aboard ship. Understanding the extent and nature of sonar exposure effects on shipboard personnel therefore is an important consideration in determining the cost-benefit ratio of alternative ship designs involving different degrees of protection from sonar exposure. The present study was part of a program to provide information on psychological effects, behavioral effects (e.g., sleep disruption), cognitive effects, and physiological effects of exposure to low frequency active sonar (LFAS) undertaken to support cost-benefit judgments about different ship design options.

Objectives and Hypotheses

The present paper reports a comparison of the effects of 77 dB and 89 dB LFAS exposure on mood and activation levels. A companion report presented evidence that although LFAS exposure adversely affected mood and activation at 83 dB and 89 dB, the magnitude of the effects was the same for both LFAS intensities (Vickers & Hervig, 1991). It was suggested that both LFAS intensities may have been above a threshold value because both produced negative effects of mood and activation. The present study provides a test of that explanation by extending the range of LFAS intensities examined to 77 dB.

The effects of 77 dB LFAS exposure were evaluated using mood and activation measures based on current theoretical models outlined by Vickers and Hervig (1991). Personality measures derived from the five-factor model of personality (Costa & McCrae, 1985) were examined as factors which might modify the reaction to LFAS exposure. Major hypotheses were:

<u>Hypothesis 1 -- Noise effects</u>: **LFAS exposure effects will be more pronounced at 89 dB than at 77 dB.**

<u>Hypothesis 2 -- Personality Effects</u>: **Personality traits will have more effect on mood and activation at 89 dB than at 77 dB.**

The first hypothesis assumes that LFAS intensity affects mood and activation. If so, these reactions to LFAS exposure provide a useful criterion for choosing between ship designs. The

second hypothesis assumes that if a person possesses a predisposition to respond to environmental stimuli, this predisposition will be activated more strongly by strong stimuli than by weak ones.

Method

Study Design

Participants were housed in the laboratory for five days during which time they completed a battery of background questionnaires, computerized cognitive performance tests, hearing tests, and a mood/activation questionnaire to assess possible effects of the sonar sound. Day 1 was introduction and familiarization with the testing laboratory and study procedures. Day 2 included baseline tests of hearing, cognitive performance and mood/activation measures. Day 3 included the 24 hour exposure to the LFAS sound and administration of all tests completed on Day 2. Day 4 included administration of the tests to examine recovery effects after termination of the sound. Day 5 provided a second recovery day to ensure that hearing levels had returned to pre-exposure levels. The study protocol was the same for all participants except for the level of LFAS exposure.

LFAS levels of 77 dB, 83 dB, and 89 dB were included in the overall study design. However, the analyses focus on the results for the 77 dB and 89 dB groups because uncontrollable factors surrounding the studies resulted in missing data on either personality or one or more mood measures for the 83 dB group. Since the primary concern of the present study was to extend the range of LFAS exposure intensities to include 77 dB, the comparison of the 77 dB and 89 dB groups provided an extreme contrast that should be maximally sensitive to differences if the reactions to LFAS exposure actually increase with LFAS intensity. On the other hand, Vickers and Hervig (1991) present evidence that increasing LFAS exposure intensity from 83 dB to 89 dB does not increase mood/activation effects and suggest that this may indicate that both intensities are above a critical threshold value. If so, the 89 dB LFAS exposure provides a reasonable representation of what would be expected at both intensities. Thus, comparison of the 77 dB and 89 dB groups would be appropriate for testing hypotheses about the effects of LFAS exposure intensities under either the increasing effects hypothesis or the threshold hypothesis.

Participants completed the protocol in groups of six, except for one group where one

participant dropped out. The result was that 12 participants completed the 77 dB protocol and 11 participants completed the 89 dB protocol.

Sample

Study participants were male Navy personnel (n=33) with an average age of 20.5 years (SD = 2.37). All participants, except for two, were recent graduates of the FC "A" School at the Naval Training Center, Great Lakes who transferred on TAD orders to Naval Submarine Medical Research Laboratory (NSMRL) to participate in the study.

Personality Assessment

The NEO Personality Inventory (Costa & McCrae, 1985) was completed on Day 1 of the study. This instrument is designed to measure five major dimensions which have been proposed as a comprehensive representation of the major domains of personality.

Neuroticism assesses adjustment versus emotional instability. This dimension identifies individuals prone to psychological distress, unrealistic ideas, excessive cravings or urges and maladaptive coping responses.

Extraversion assesses quantity and intensity of interpersonal interactions, activity level, need for stimulation, and capacity for joy.

Openness to experience assesses proactive seeking and appreciation of experience for its own sake. This dimension looks at the tolerance for and exploration of the unfamiliar.

Conscientiousness assesses an individual's degree of organization, persistence and motivation in goal-directed behavior. Extreme scores contrast dependable, fastidious people with lackadaisical and sloppy people.

Agreeableness assesses the quality of one's interpersonal orientation along a continuum from compassion to antagonism in thoughts, feelings and actions.

Personality Characteristics of Participants. The personality profile for study participants was of interest because of implications for generalizing study findings to operational fleet environments. Significant differences from participants in the companion LFAS study or normative samples might suggest bias in this study sample and make extension of the findings to other settings difficult. Participants had a significantly lower average for neuroticism, and higher average for openness to experience than Navy recruits and a higher average for

extraversion and openness to experience than participants in the companion LFAS study. Study participants were similar to the other LFAS study participants in their lower than average score on neuroticism than the recruits, but not on the higher than average mean on conscientiousness. Group means of the individual personality dimensions and t-tests comparing the study sample with both the participants in the companion study and graduating Navy recruits are presented in Table 1.

Table 1

Personality Profile of LFAS Study Participants Compared with Concurrent LFAS Study and Normative Profiles

	Current Study		Vickers & Hervig			Recruits			
Scale	Mean	SD	Mean	SD	t-test sig	Mean	SD	t-test sig	Var Ratio
Neuroticism	1.73	.33	1.72	.35	.425	1.94	.42	.002	.64
Extraversion	2.48	.29	2.33	.36	.004	2.41	.36	.110	.64
Openness to Experience	2.44	.28	2.23	.36	.001	2.30	.34	.009	.71
Conscientiousness	2.58	.44	2.68	.38	.127	2.54	.51	.302	.75
Agreeableness	2.39	.38	2.32	.31	.163	2.37	.39	.406	.96

NOTE: *t*-test results based on comparison of present means to the means for participants in the concurrent LFAS study (n=45; Vickers & Hervig, 1991), and recruits who graduated from basic training (n = 2240 - 2248). Variance ratios results are based on comparison of the study variances to the variances for the recruits.

Mood Assessment

Mood was measured by a 51-item questionnaire based primarily on the 40-item Mood Questionnaire (MQ) of Ryman, Biersner, and LaRocco (1974). The 11 additional items were chosen to cover the range of scales in Thayer's Activation-Deactivation Adjective Check List (AD-ACL; Thayer, 1989) and to provide a measure of interpersonal warmth similar to that in the Profile of Mood States (McNair, Lorr, & Droppleman, 1971). Scale item content was:

Anger: irritated, mean, burned-up, grouchy, annoyed, angry

Happiness: contented, steady, happy, pleased, satisfied, good

Anxiety: afraid, alarmed, uneasy, hopeless, insecure

Depression: low, blue, miserable, downcast, depressed, sad

Warmth: friendly, accepting, good-natured, kindly, warm-hearted, forgiving

Energy: lively, active, energetic, vigor, full-of-pep

Fatigue: sleepy, tired, drowsy, wakeful, wide-awake

Tension: jittery, clutched-up, intense, fearful, tense

Calm: calm, placid, at rest, still, quiet

The mood checklist was administered twice a day throughout the study. The first daily administration was between 0800 and 0900 and the second administration was between 2100 and 2200. Only data from the day preceding the onset of the LFAS, the day of exposure to LFAS, and the day after exposure to LFAS were used in the analyses reported. The novelty of the setting and the initial exposure to the research procedures made mood and activation measures from the first day in the laboratory unsuitable as baseline measures. Thus, the mood data were analyzed as a baseline-exposure-recovery sequence.

Analysis Procedures

Analyses were conducted with the SPSS-X statistical package (SPSS, Inc., 1988). The effects of LFAS exposure were evaluated by multivariate analyses of variance (MANOVAs) for repeated measures. In these analyses time of day (Morning versus Evening) and day of testing (Baseline versus Exposure versus Recovery) defined completely-crossed within-person factors. LFAS intensity (77 dB versus 89 dB) defined a between-person factor. A separate analysis was conducted for each mood measure. Because these MANOVAs required mood measures from all six administrations, sample sizes for the 77 dB and 89 dB groups for these analyses were 6 and 10, respectively.

Hypotheses concerning personality were tested by 2 x 2 analyses of variance with personality (Low versus High) and LFAS Intensity (77 dB versus 89 dB) as between-persons factors. Since time of day was not a significant factor for any of the mood responses to LFAS in the initial MANOVAs, the personality by LFAS intensity MANOVAs employed mood measures which were collapsed across time of day. Separate analyses were conducted for each personality dimension with low scorers defined as those falling below the sample mean and high scorers as

those above the sample mean on each dimension.

Mood scores were treated differently in the personality by LFAS intensity MANOVAs because the results of the initial LFAS intensity x Day x Time of Day MANOVAs suggested that relaxing the requirements for complete data could increase sample size without biasing estimates of the effects of interest when considering personality. Since there were no significant time of day effects (see below), the morning and evening mood measures were averaged. A single mood measure was used for cases where one measure was missing. Thus, the personality x LFAS intensity analyses included all those individuals who provided at least one mood measurement per day (n = 12 for 77 dB; n = 11 for 89 dB) because a measure taken in the morning or the evening would be an unbiased estimate of the mood for the day given the absence of time of day effects. Each mood and activation measure was considered separately for both exposure effects and recovery rates which were defined as:

Exposure effect = Mood during LFAS exposure - Mood the previous day

Recovery rate = Mood the day after LFAS exposure - Mood during LFAS exposure

Measures of exposure effects and recovery rates were computed using the average mood scores for the entire day. Additional product-moment correlation analyses were conducted to determine the relationship between personality and mood effects of LFAS exposure when personality was treated as a continuous variable rather than a dichotomy.

Pooled Findings. The results of the present study were combined with those of another study conducted concurrently at the Naval Health Research Center (Vickers & Hervig, 1991). Formal statistical analysis of the combined results of the two studies was desirable because the sample sizes in the two studies considered separately were not large. As a result, it would be possible for cumulatively significant trends from the two studies to appear nonsignificant even though they might be large enough to be of practical interest (Tversky & Kahneman, 1970).

The pooling procedures involved the computation of weighted average effect sizes and pooled significance levels based on the data from the two studies. Effect size estimates were computed for each study following procedures described by Cohen (1969). The effect sizes were combined across the two studies by taking weighted averages with sample size as the weighting factor. Pooled significance estimates for the two studies were computed using the methods of adding probabilities and adding *t*s (Rosenthal, 1978). Decisions about the significance of the combined

results were determined by whether the observed effect was in the same direction in both studies, whether the absolute magnitude of the weighted effect size exceeded Cohen's (1969) suggested criterion for a small effect, and whether the combined probabilities for the effects observed in the two studies exceeded the $p < .05$ level.

Results

LFAS Exposure Effects

Simple exposure effects of LFAS were defined as the average effect of being exposed to LFAS computed across both levels of LFAS intensity. In the analyses, simple exposure effects were represented by main effects of day and time of day. The day effects in the MANOVAs showed that LFAS exposure was associated with decreased positive affect (calm) and a trend for increased negative reactions (fatigue and tension). Time of day did not affect significantly any mood or activation report in this study.

The influence of personality on simple exposure effects was investigated by correlational analyses. LFAS exposure effects were more likely to correlate significantly ($p < .05$) with personality (3 of 45) than were LFAS recovery effects (1 of 45). These simple exposure effects are not considered further here because they do not bear on whether LFAS exposure at 89 dB produced different effects than LFAS exposure at 77 dB. Details of the findings are provided for the interested reader in Appendix A.

Effects of Different LFAS Intensities. Any differential effect of 77 dB LFAS compared to 89 dB LFAS would have been evident in two interaction effects in the Intensity x Day x Time of Day MANOVAs. If LFAS intensity affected mood over the entire 24-hour exposure period, the effects should be identifiable as an Intensity x Day interaction. If noise intensity affected mood only at a particular time of day, there would be a significant Intensity x Day x Time of Day interaction. The overall set of analyses provided 18 significance tests for these interactions (2 interactions x 9 mood/activation measures). Only the Intensity x Day interaction for calm was significant ($p = .038$). Application of binomial probability computations, indicate that there is a greater than 50% probability that at least one interaction will have an associated probability of $p = .038$ or less when 18 significance tests are conducted. However, the present significance tests are not completely independent because the moods are correlated, so it could be argued that

fewer than 18 independent significance tests were performed. It is of interest, therefore, to note that obtaining a single difference which was significant at the $p = .038$ level would yield an experiment-wide error greater than .05 by Bonferroni procedures if as few as two significance tests were performed (Dunn, 1958).

Personality and Reactions to LFAS Exposure. It was hypothesized that the relationship between personality and mood would be more pronounced at the higher dB levels. Only 4 of 90 personality x LFAS intensity interactions (5 personality dimensions with 9 mood/activation measures for exposure and recovery) were statistically significant (Neuroticism with fatigue for LFAS exposure, $p < .045$; Conscientiousness with warmth for LFAS exposure, $p < .042$; Openness to Experience with depression for LFAS recovery, $p < .017$; Conscientiousness with energy for LFAS recovery, $p < .035$).

Table 2
Correlations of Personality and Mood/Activation
During LFAS Exposure

Personality Scale	Mood/Activation Scale	77 dB r	89 dB r
Exposure Effect			
Neuroticism	Fatigue	.60	-.28
		(-.62)	(.30)
Conscientiousness	Warmth	.57	-.40
		(.48)	(.08)
Recovery Rate			
Openness to Experience	Depression	.68	-.29
		(.46)	(-.07)
Conscientiousness	Energy	-.36	.53
		(-.62)	(-.20)

NOTE: Figures in parentheses are the corresponding correlations taken from the sample studied by Vickers and Hervig (1991) for 83 dB (listed in Table 2 as 77 dB) and 89 dB.

Even where significant effects were obtained, the results did not fit the predicted pattern. When the interactions were expressed as point-biserial correlations between the dichotomized

personality measures and the dependent variables (see Table 2), all 4 significant interactions involved correlations which had opposite signs at 77 dB and 89 dB. Also, in each instance, the absolute value of the correlation was larger in the 77 dB group.

The statistically significant differences obtained in this study also were compared to the results of similar analyses by Vickers and Hervig (1991) which contrasted correlations obtained at 83 dB and 89 dB. If the effects of personality vary with LFAS intensity, this comparison might be expected to show similar trends in the two samples, but smaller differences in the prior study because of the smaller difference in LFAS intensities. There was no consistent trend to support this expectation (Table 2).

Pooled Findings

The analyses reported to this point were based on a single sample with a limited number of subjects studied at each LFAS intensity level. This small sample size means that statistical tests have low power, so even moderately large effects of LFAS could be overlooked on the basis of statistical significance testing in this sample alone (Cohen, 1969). Combining the results from two or more samples can help overcome decision biases resulting from low statistical power (Tversky & Kahneman, 1970). The combined results from this study and the concurrent research reported by Vickers and Hervig (1991) therefore were examined statistically using procedures described by Rosenthal (1978).

A cautionary note is appropriate before considering the results of these pooled analyses, however. The studies are not directly comparable because they differed in LFAS intensity. Thus, the pooled findings provide a method for identifying comparable trends in the two studies, but not for demonstrating that any specific parameter value (i.e., difference between low and high dB LFAS exposure) was directly replicated in the two studies.

The pooled analyses basically presented the same picture as the results of this study when it was considered alone. Several reliable effects were observed for simple exposure to and recovery from LFAS (Appendix A), but there was no evidence that the size of these effects differed as a function of LFAS intensity. Seven effects involving LFAS intensity produced significant ($p < .05$) combined results. These effects for LFAS exposure were the Neuroticism x Intensity interaction for warmth ($p < .02$), energy ($p < .003$), and fatigue ($p < .002$); Extraversion x Intensity interaction for fear ($p < .008$) and depression ($p < .05$); Openness x

Intensity interaction for calm ($p < .03$); and Conscientiousness x Intensity interaction for warmth ($p < .02$). Only the Openness x Intensity interaction for depression ($p < .03$) was significant for recovery after LFAS was stopped. In all cases, examination of the means which produced the interactions showed that the form of the interaction was different in the two studies. When this observation is combined with the fact that 117 total interaction possibilities were examined in the pooled analyses, it is reasonable to assert that there were no nonchance interactions involving LFAS.

Discussion

The findings from the present study replicated Vickers and Hervig's (1991) results qualitatively and substantially extended the range of LFAS intensities considered. This central finding implies that if there is some threshold level at which LFAS exposure begins to affect mood, it is below 77 dB. As a result, LFAS intensities in the 77 dB to 89 dB range can be considered equivalent with regard to their influence on mood. If ship design criteria for soundproofing are limited to LFAS intensities in the 77 dB to 89 dB range, short-term mood effects provide no basis for choosing between alternatives. Other criteria such as effects on cognitive performance, sleep disruption, and so on provide alternative behavioral criteria which may be sensitive to LFAS intensities in this range. Other studies from this project address the effects of LFAS exposure on these criteria.

Two limitations of the study must be considered when generalizing these findings to make assertions about mood and activation effects of LFAS in operational settings. First, participants in both studies of LFAS exposure scored lower on neuroticism than the average graduating Navy recruit (Table 1). Vickers and Hervig (1991) reported a wider range of personality differences between their sample and the reference recruit sample. However, the other aspects of personality which differed significantly from the reference Navy recruit population in the earlier study either showed small differences in the same direction or even were in opposite directions when the two studies were considered together. At this time, therefore, neuroticism is the only personality dimension that showed consistent differences in both studies.

The consistent differences between the samples and the reference population with respect to neuroticism may distort the findings regarding LFAS exposure effects. The restricted range

of neuroticism scores would yield misleading results if highly neurotic individuals reacted more strongly to lower intensity LFAS. If so, it might be appropriate to consider this susceptible population as the primary reference point for deciding between alternative exposure intensities. At present, there is no reason to believe that reactions to different LFAS intensities would differ even in extremely neurotic individuals. This statement is justified by the lack of any reliable trends suggesting neuroticism by intensity interactions which might be expected if moderate neuroticism scores provided weaker indications of the effects of extreme neuroticism. This expectation would not hold if there were some marked discontinuity in the effects of neuroticism on reactions to LFAS. If so, more intense mood and activation responses to more intense LFAS might emerge relatively suddenly when neuroticism scores were above a threshold which few study participants exceeded. However, even if this "emergent effect" situation applied for extreme neuroticism scorers, there may be few of these individuals in the population of interest. People with neurotic tendencies tend to be poor job performers and may be more likely to attrite from the service following basic training. If so, the continuing attrition process after basic training may account for the observed trends toward lower neuroticism scores in our sample. In this case, the lower frequency of individuals high on neuroticism seen in the two studies may be typical of the fleet, and this issue would not be a problem in generalizing the findings to the fleet. Even if this is not the case, it would remain to be shown that extremely neurotic individuals were more sensitive to more intense LFAS exposures.

A second potentially important limitation of the available evidence is that participants in both LFAS studies were exposed to LFAS for a relatively short time period. Longer exposures to LFAS are likely to occur in operational settings, and caution is appropriate when extrapolating from the findings for short exposures to longer exposures. Additional research involving longer periods of study with LFAS exposure patterns designed to simulate exposures that could be expected in operational conditions would be a reasonable extension of the present short-term exposures.

Conclusion

Exposure to LFAS influences mood and activation, particularly in people whose personalities predispose them to respond, but the magnitude of the exposure effects is not related to LFAS intensity over the 77 dB to 89 dB range. Mood and activation effects, therefore, do not

provide criteria for choosing between alternative ship designs that would result in LFAS exposure intensities in this range.

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Appendix A

Table A-1
Effects of Noise on Mood:
Mean Exposure Effects (E) and Recovery Rates (R)

		Present Study		Vickers & Hervig		Combined:		Effect
		Average	Sig[1]	Average	Sig[1]	Average	Sig[2]	Size
Mood States								
Happy	E	-.116	.031	-.168	.004	-.150	.001	0.90
	R	-.003	.482	.024	.306	.015	.339	0.10
Warmth	E	-.239	.014	-.214	.002	-.223	.0001	1.02
	R	.023	.393	.064	.109	.050	.126	0.30
Anger	E	-.004	.478	.270	.004	.176	.138	0.57
	R	-.012	.351	-.216	.009	-.146	.065	0.59
Fear	E	-.029	.134	.045	.120	.020	.486	0.08
	R	-.010	.333	-.015	.378	-.013	.253	0.13
Depression	E	-.007	.469	.120	.037	.076	.161	0.37
	R	.000	.500	-.125	.023	-.082	.137	0.43
Activation States								
Calm	E	-.232	.005	-.075	.056	-.131	.002	0.78
	R	.086	.145	-.018	.309	.019	.677	-0.06
Energy	E	-.057	.275	-.126	.019	-.102	.043	0.54
	R	.086	.217	.124	.008	.111	.025	0.66
Tired	E	.191	.007	-.089	.066	.010	.560	-0.10
	R	-.078	.237	-.035	.299	-.050	.144	0.22
Tension	E	.062	.057	.053	.176	.056	.027	0.45
	R	-.071	.026	-.050	.176	-.057	.020	0.52

[1] Significance levels are one-tailed probabilities taken from analysis of variance results. One-tailed significance was appropriate given a priori hypotheses about the nature of LFAS exposure effects.

[2] Pooled one-tailed significance levels using method of Rosenthal (1978).

Table A-2
Correlations Between Personality and Mood Effects of Sonar Noise

Personality Dimension	Mood Scale	r	1-tailed sig.	Aver r*	Pooled sig.
Exposure Effects					
Neuroticism	Calm	-.141	.261	-.263	.038
Extraversion	No reliable associations				
Openness	Energy	.324	.066	.213	.027
	Happy	.325	.065	.224	.022
Conscientiousness	Anger	.320	.069	.091	.214
	Calm	.335	.059	.246	.013
	Happy	.238	.137	.244	.019
Agreeableness	Calm	.531	.005	.347	.002
	Energy	.418	.024	.341	.001
	Happy	.354	.049	.226	.023
	Warmth	.294	.087	.171	.059
Recovery Rate					
Neuroticism	Fear	-.135	.270	-.207	.055
	Tired	-.103	.320	-.205	.068
Extraversion	Calm	.292	.089	-.013	.534
	Tense	-.290	.090	-.186	.047
	Tired	-.171	.218	-.243	.033
Openness	Energy	.290	.089	.403	.004
	Warmth	.293	.088	.210	.031
	Happy	.072	.372	.213	.082
Conscientiousness	Tension	-.208	.170	-.207	.037
	Tired	-.303	.080	-.240	.017
Agreeableness	Energy	-.330	.062	-.077	.261
	Tension	-.414	.025	-.136	.171

* Table entries represent all correlations which were significant ($p < .10$, one-tailed) in the present sample or which produced a weighted average r greater than .20 (absolute) when the present results were combined with the results of Vickers and Hervig (1991) using sample size as the weighting factor. Pooled significance was computed by the method of adding probabilities (Rosenthal, 1978).

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P. O. Box 85122
San Diego, CA 92186-5122

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13. ABSTRACT *(Maximum 200 words)*

Navy personnel are exposed to low frequency active sonar (LFAS) as part of their normal work environment and adverse effects on health, performance, or morale may result. These adverse effects of LFAS can be reduced by ship design modifications, (e.g., soundproofing), but increased costs are an important concern. This study examined the effects of 24-hour LFAS exposure on mood and activation at LFAS intensity levels of 77 dB (n=12) and 89 dB (n=11). Significant mood and activation changes were observed during LFAS exposure and recovery, but the magnitude of these changes was the same at both intensities. Personality variables predicted how individuals responded to LFAS exposure, but relationships between personality and mood/activation were not affected by LFAS intensity. These findings were consistent with a concurrent study which examined the effects of LFAS exposure at 83 dB and 89 dB. These current findings do not support a concern for ship design when LFAS is in the 77 dB and 89 dB range unless these findings change under longer LFAS exposure times which may be more typical of Navy shipboard environments during operational deployments.

14. SUBJECT TERMS
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